REMARKS

This Amendment is submitted in response to the Office Action dated April 4, 2006. In the Office Action, the Patent Office rejected Claims 26-32 under 35 U.S.C. § 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention.

By the present amendment, Applicant submits that this response overcomes the rejection to the claims by the Patent Office.

In the present Office Action, the Patent Office rejected Claims 26-32 under 35 U.S.C. § 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention. More specifically, the Patent Office alleges that Specification fails to disclose how the combination alarm and locator system 10 is implemented so that it can possibly determine its location and transmit a location signal to a plurality of satellites for determining the location of the device. Applicant respectfully submits that the rejection under 35 U.S.C. §112 is invalid and devoid of any explanation why the Patent Office has rejected the claims Applicant has previously illustrated to the Patent Office where in the specification support for the claims are illustrated. Yet, the Patent Office has again rejected on the same basis and has not illustrated any reasoning for its rejection. In a telephone communication with the Examiner, the Examiner indicated that there are no hand held devices that communicate with a satellite. Applicant has submitted herewith, examples of different devices that communicate that send a signal to a satellite.

Moreover, applicant respectfully points that GPS hand held devices all send a signal to a satellite. Most GPS units typically send a signal to a ground station which in turn sends the signal to the satellite. However, it should be understood that the GPS device is still sending a signal to the satellite even if the communication is not direct.

The test of enablement is whether one skilled in the art could make or use the claimed invention from the disclosure in the patent coupled with information known in the art without undue experimentation. MPEP 2164.01. Further, a patent need not teach, and preferably omits, what is well known in the art. *In re Buchner*, 929 F.2d 660, 661, 18 USPQ2d 1331, 1332 (Fed.

Cir. 1991); *Hybritech, Inc. v. Monoclonal Antibodies, Inc.*, 802 F.2d 1367, 1384, 231 USPQ 81, 94 (Fed. Cir. 1986), *cert. denied*, 480 U.S. 947 (1987); and *Lindemann Maschinenfabrik GMBH v. American Hoist & Derrick Co.*, 730 F.2d 1452, 1463, 221 USPQ 481, 489 (Fed. Cir. 1984) The state of the art existing on the filing date of the application is used to determine whether a particular disclosure is enabling as of the filing date.

The fact that experimentation may be complex does not necessarily make it undue. If the art typically engages in such experimentation. *In re Certain Limited-Charge Cell Culture Microcarriers*, 221 USPQ 1165, 1174 (Int'l Trade Comm"n 1983), *aff'd. sub nom., Massachusetts Institute of Technology v. A.B. Fortia*, 774 F.2d 1104, 227 USPQ 428 (Fed Cir. 1985). See also *In re Wands*, 858 F 2d at 737, 8 USPQ2d at 1404. The test of enablement is not whether any experimentation is necessary, but whether, if experimentation is necessary, it is undue. *In re Angstadt*, 537 F.2d 498, 504, 190 USPQ 214, 219 (CCPA 1976).

Whether undue experimentation is needed is not based upon a single factor, but rather a conclusion reached by weighing many factors. Many of these factors have been summarized in *In re Wands*, 858 F 2d 731, 98 USPQ2d 1400 (Fed. Cir. 1988) (reversing the PTO's determination that claims directed to methods for detection of hepatitis B surface antigens did not satisfy the enablement requirement). as follows:

(1) The Scope/Breadth of the Claims

(2) The Nature of the Invention

(3) The State of the Art

(4) The Relative Skill in the Art

(5) The Amount of Direction or Guidance Present

(6) The Predictability or Unpredictability of the Art

(7) The Presence or Absence of Working Examples

(8) The Quantity of Experimentation needed

In *Wands*, the court noted that there was no disagreement as to the facts, but merely a disagreement as to the interpretation of the data and the conclusion to be made from the facts. *In re Wands*, 858 F.2d at 736-40, 8 USPQ2d at 1403-07. The Court held that the specification was enabling with respect to the claims at issue and found that "there was considerable direction and guidance" in the specification; there was "a high level of skill in the art at the time the application was filed;" and "all of the methods needed to practice the invention were well known." 858 F.2d at 740, 8 USPQ2d at 1406. After considering all the factors related to the enablement issue, the court concluded that "it would not require undue experimentation to obtain antibodies needed to practice the claimed invention." *Id.*, 8 USPQ2d at 1407.

It is improper to conclude that a disclosure is not enabling based on an analysis of only one of the above factors while ignoring one or more of the others. The examiner's analysis must consider all the evidence related to each of these factors, and any conclusion of nonenablement must be based on the evidence as a whole. 858 F.2d at 737, 740, 8 USPQ2d at 1404, 1407.

Here, claimed subject matter as a whole is enabled by the direction and guidance provided in the application The amount of guidance or direction needed to enable the invention is inversely related to the amount of knowledge in the state of the art as well as the predictability in the art. *In re Fisher*, 427 F.2d 833, 839, 166 USPQ 18, 24 (CCPA 1970). The "amount of guidance or direction" refers to that information in the application, as originally filed, that teaches exactly how to make or use the invention. The more that is known in the prior art about the nature of the invention, how to make, and how to use the invention, and the more predictable the art is, the less information needs to be explicitly stated in the specification.

Going through an analysis of the specification in the application, it is plainly obvious that the specification most certainly discloses how the combination alarm and locator system can determine its location and transmit a location signal to a plurality of satellites for determining the location of the device.

As illustrated in the last response, the applicant would like to point out the following instances within the specification that sufficiently discloses how device 10 can determine its location and transmit a location signal to a plurality of satellites:

Page 15, lines 3-5 of the bottom paragraph.

Page 16, lines 2-5 of the top paragraph

Page 26, lines 7-14.

Page 27, lines 6-21.

Page 28, top paragraph.

Page 28, lines 5-8 of second paragraph.

Page 28, lines 5-9 of bottom paragraph.

Page 29, top paragraph.

Page 30, lines 3-4 of top paragraph.

Page 33, lines 1-5 of top paragraph.

Page 33, lines 1-9 of bottom paragraph.
Page 34, lines 1-9 of top paragraph.

Moreover, a look at paragraph 55 further illustrates how the system words.

"A combination vehicle alarm and locator device is disclosed by the present invention. The device includes a housing, a vehicle alarm activator positioned within the housing including a transmitter for activating an alarm system on a vehicle and an infrared transmitting device located in the housing for communicating with a Global Positioning Satellite system for determining a location of the device." It should be fully understood that the device has a infrared transmitting device to

communicate with a GPS system. Moreover, a person of ordinary skill in the art would understand that GPS systems utilize radio frequency to communicate with like devices. Additionally, a person of ordinary skill in the art would understand the communication between the hand held unit and the satellite.

The claimed subject matter requires general understanding of satellite transmission technology, more specifically, GPS technology. One of ordinary skilled in the art would understand how a GPS receiver works with a plurality of satellites to detect the location of the GPS receiver. A working example is a GPS device installed in a vehicle to inform the driver where the vehicle is. Typical GPS device in a vehicle, however, does not transmit a signal containing location information back to the satellite. The claimed device has a memory that keeps location information and then transmits this location information via satellites to a third party. Transmitting such location signal back to the satellite to inform a third party requires understanding of satellite transmission technology. Much is already known about transmitting signals via satellites and about various devices capable of making such transmission via satellites. In view of a well understood satellite transmission technology, the specification sufficiently provides direction and guidance, as originally filed, teaching exactly how to make and use the invention.

Claims 27-31 depend from Claim 26. These claims are further believed allowable for the same reasons set forth with respect to independent Claim 26 since each sets forth additional novel components and steps of Applicant's Combination Car Alarm and Personal Locator System.

<u>Request For Allowance</u>

In view of the foregoing remarks, Applicant respectfully submits that all of the claims in the application are in allowable form and that the application is now in condition for allowance. If any outstanding issues remain, Applicant urges the Patent Office to telephone Applicant's attorney so that the same may be resolved and the application expedited to issue. Applicant requests the Patent Office to indicate all claims as allowable and to pass the application to issue.

Respectfully submitted,

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Satellite Phone Information

Major Telecommunication Satellite Constellations

Inmarsat Satellite

The major telecommunication satellite constellations are: Globalstar, Inm. Iridium. These are also the three major satellite phone services.

Globalstar launched commercial services in 1999 and today assert that thei are the most widely used in the world. Customers can use their phones in mor countries on six continents, as well as from most territorial waters and se ocean regions. Globalstar signals are received by the company's constellation Earth Orbiting (LEO) satellites and relayed to ground-based gateways, which the call on to the terrestrial telephone network.

(Terrestrial-of or relating to the earth and is a term used in satellite techr distinguish between what is out in space and what is located on the earth's sur

Globalstar satellite phone service is delivered through special multi-mode pho work just like traditional cellular phones when in an area with cellular cover: the user needs to communicate from outside the area covered by gro systems, the phones easily switch to Globalstar satellite mode. Satellite a communications are both available in one phone.

Inmarsat was the world's first global mobile satellite communications op states it is still the only one to offer a mature range of modern communicatio to maritime, land-mobile, aeronautical and other users. Formed 20 years international maritime organization, Inmarsat was reorganized as a limited c 1999 and has broadened its customer base

Inmarsat's primary satellite constellation consists of four Inmarsat I-3 s geostationary orbit. A fifth spacecraft that can be brought in to provide capacity currently backs these up. Between them, the main "global" bea satellites provide overlapping coverage of the whole surface of the Earth apa poles. So, with Inmarsat coverage, it has become possible to extend the terrestrial wired and cellular networks to almost anywhere on Earth.

Iridium claims to be the "only provider of truly global, truly mobile satellite data solutions with complete coverage of the Earth (including oceans, airways regions). Eighty-six percent of the world's landmass and all of its oceans ar with inadequate landline service. Iridium addresses these situations by coverage in all ocean areas, air routes and all landmasses-even the Poles.

Sixty-six low-earth-orbiting (LEO) satellites provide global coverage, which al to make and receive calls virtually anywhere in the world. The only require clear line of sight to the sky. Their services are aimed most heavily toward users in heavy construction, defense/military, emergency services, maritim forestry, oil and gas and aviation.

Satellite phone

From Wikipedia, the free encyclopedia

A **satellite telephone**, **satellite phone**, or **satphone** is a mobile phone that communicates directly with orbiting communications satellites. Depending on the architecture of a particular system, coverage may include the entire Earth, or only specific regions.

The mobile equipment, also known as a terminal or earth station, varies widely. A satellite phone handset has a size and weight comparable to that of a late 1980s or early 1990s cell phone, but with a large retractable antenna. These are popular on expeditions into remote areas where terrestrial cellular service is unavailable.


Satellite phone (Inmarsat)

A fixed installation, such as used shipboard, may include large, rugged, rack-mounted electronics, and a steerable microwave antenna on the mast that automatically tracks the overhead satellites

Geostationary services

Some satellite phones use satellites in geostationary orbit. These systems can maintain near-continous global coverage with only three or four satellites, reducing the launch costs. The major satellite system in civilian use is Inmarsat.

The disadvantage of geostationary satellite systems is that the inverse square law means that a comparatively large antenna system is required for signal transmission and reception for the phone. The phone system must therefore be quite physically large that is similar to the size of terrestrial mobile phones in the past, compared to the current tiny terrestrial mobile phones.

Low Earth orbit

LEO telephones utilizes LEO (low Earth orbit) satellite technology. The advantages include providing worldwide wireless coverage with no gaps. All satellite phones tend to be LEOs. LEO satellites orbit the earth at high speed, low altitude orbits with an orbital time of 70–90 minutes, an altitude of 640 to 1120 kilometres (400 to 700 miles), and provide coverage cells. Since the satellites are not geosynchronous, they must fly complete orbits and thus further guarantee complete coverage over every area by at least one satellite at all times. Blimps are being considered as an alternative to satellites

The two deployed LEO satellite systems are Iridium and Globalstar. Customer numbers for both systems never matched the levels required to fund the large number of satellite launch costs, and both went into bankruptcy. They are now operated by new owners who bought the assets for a fraction of their original cost.

There are several models of satellite phones available

Satellite phones in pop culture

In the movie *Jurassic Park III*, Alan Grant lends his satellite phone (Globalstar handset) to Nash. Then, the dinosaur eats him and the phone is found in the dinosaur's feces. The satellite phone was also used many times on

the show *Relic Hunter*. The main character, Sydney Fox, would use it to communicate back home when she found interesting relics. Also such phones are said to be difficult to trace which makes them a popular favorite for criminals.

Retrieved from "http://en.wikipedia.org/wiki/Satellite_phone"

Categories: Satellite telephony

- This page was last modified 10:39, 22 May 2006.
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Global Positioning System

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From Wikipedia, the free encyclopedia
(Redirected from GPS)

GPS redirects here. For other uses of the acronym GPS, see GPS (disambiguation).


GPS satellite in orbit, image courtesy NASA

The **Global Positioning System**, usually called **GPS**, is the only fully-functional satellite navigation system. A constellation of more than two dozen GPS satellites broadcasts precise timing signals by radio to GPS receivers, allowing them to accurately determine their location (longitude, latitude, and altitude) in any weather, day or night, anywhere on Earth.

GPS has become a vital global utility, indispensable for modern navigation on land, sea, and air around the world, as well as an important tool for map-making, and land surveying. GPS also provides an extremely precise time reference, required for telecommunications and some scientific research, including the study of earthquakes.

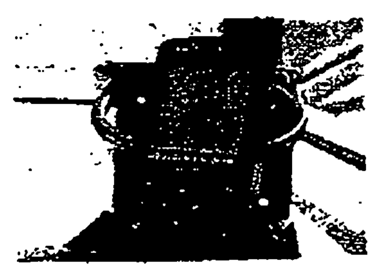
United States Department of Defense developed the system, officially named **NAVSTAR GPS** (Navigation Signal Timing and Ranging GPS), and the satellite constellation is managed by the 50th Space Wing at Schriever Air Force Base. Although the cost of maintaining the system is approximately US$400 million per year, including the replacement of aging satellites, GPS is available for free use in civilian applications as a public good.

In late 2005, the first in a series of next-generation GPS satellites was added to the constellation, offering several new capabilities, including a second civilian GPS signal called **L2C** for enhanced accuracy and reliability. In the coming years, additional next-generation satellites will increase coverage of L2C and add a third and fourth civilian signal to the system, as well as advanced military capabilities.

The Wide-Area Augmentation System (WAAS), available since August 2000, increases the accuracy of GPS signals to within 2 meters (6 ft) [1] for compatible receivers. GPS accuracy can be improved further, to about 1 cm (half an inch) over short distances, using techniques such as Differential GPS (DGPS).

Contents


Over fifty GPS satellites such as this NAVSTAR have been launched since 1978


Magellan GPS receiver in a marine application

Applications

- **Military Applications of DESTRUCTION**

GPS allows accurate targeting of various military weapons including, cruise missiles and precision-guided munitions, as well as improved command and control of forces through improved locational awareness. The satellites also carry nuclear detonation detectors, which form a major portion of the United States Nuclear Detonation Detection System. Civilian GPS receivers are required to have limits on the velocities and altitudes at which they will report coordinates; this is to prevent them from being used to create improvised missiles. [2]

- **Navigation**

Main article: Automotive navigation system

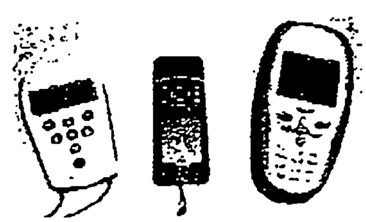
This taxi in Kyoto, equipped with GPS navigation, is an example of how GPS technology can be applied in routine activities.

GPS is used by people around the world as a navigation aid in cars, airplanes, and ships. The system can also be used by computer controlled harvesters, mine trucks and other vehicles. Hand-held GPS receivers can be used by mountain climbers and hikers. Glider pilots use the logged signal to verify their arrival at turnpoints in competitions. Low cost GPS receivers are often combined in a bundle with a PDA, car computer, or vehicle tracking system. GPS equipment is even available for the visually impaired.

- **Surveying**

More costly and precise receivers are used by land surveyors to locate boundaries, structures, and survey markers, and for road construction.

- **Geocaching**



The availability of hand-held GPS receivers for a cost of about $90 and up (as of March 2005) has led to recreational applications including Geocaching. Geocaching involves using a hand-held GPS unit to travel to a specific longitude and latitude to search for objects hidden by other Geocachers. This popular activity often includes walking or hiking to natural locations.

- **GPS usage by aircraft passengers**

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Most airlines allow passenger use of GPS units on their flights, except during landing and take-off when other electronic devices are also restricted. Even though inexpensive consumer GPS units have a minimal risk of interference, there is still a potential for interference. Because of this possibility, a few airlines disallow use of hand-held receivers for safety reasons. However, other airlines integrate aircraft tracking into the seat-back television entertainment system, available to all passengers even during takeoff and landing.[3]

GPS receivers come in a variety of formats, from devices integrated into cars, phones, and watches, to dedicated devices such those shown here from manufacturers Trimble, Garmin and Leica (respectively, left to right).

- **Precise time reference**

Many systems that must be accurately synchronized use GPS as a source of accurate time. For instance, the GPS can be used as a reference clock for time code generators or NTP clocks. Also, when deploying sensors (for seismology or other monitoring application), GPS may be used to provide each recording apparatus with a precise time source, so that the time of events may be recorded accurately. Communications networks often rely on this precise timing to sycronize RF generating equipment, network equipment and multiplexers. Withought this precise timing, sychronization timing errors would be substantial causing a high BER (bit error rate) and or unstable TX/RX frequencies resulting in sporatic signal loss which is known as "timing jitter". Multiplexers might loose whole frames of data which could cause dropped calls.

Even fixed systems may use GPS, in order to get precise time. This antenna is mounted on the roof of a hut containing a scientific experiment needing precise timing

The atomic clocks on the satellites are set to "GPS time", which is the number of seconds since 00:00:00 UTC, January 6, 1980. Today, GPS time is 14 seconds ahead [4] of UTC, because it does not follow leap seconds. Receivers thus apply a clock-correction offset (which is periodically transmitted along with the other data) in order to display UTC correctly, and optionally adjust for a local time zone. New GPS units will initially show the incorrect time after achieving a GPS lock for the first time. However, this is usually corrected on the display within 15 minutes once the UTC offset message is received for the first time.

- **Geophysics and Geology**

High precision measurements of crustal strain can be made with GPS by finding the relative displacement between GPS sites, one of which is assumed to be stationary. Multiple stations situated around an actively deforming area (such as a volcano or fault zone) can be used to find strain and site velocities relative to a stable reference site. These measurements can then be inverted using the relationships between stress and strain to interpret the source and cause of the deformation. For example, measurements of ground deformation around a volcano can be used to intrepret the source and cause - a dike, sill, or other body beneath the surface.

- **Location-based services**

GPS functionality is opening up new and innovative ways to use search in mobile phones. In the future mobile units could be equipped with GPS technology, such as Assisted GPS, which could be coupled with web search tools to allow users to search keywords and have their results be returned that are specific to their geographic locations.

History

The design of GPS is based partly on the similar ground-based radio navigation systems, such as LORAN developed in the early 1940s, and used during World War II. Additional inspiration for the GPS system came when the Soviet Union launched the first Sputnik in 1957. A team of U.S. scientists led by Dr Richard B. Kershner were monitoring Sputnik's radio transmissions. They discovered that, due to the Doppler effect, the frequency of the signal being transmitted by Sputnik was higher as the satellite approached, and lower as it continued away from them. They realized that since they knew their exact location on the globe, they could pinpoint where the satellite was along its orbit by measuring the Doppler distortion. It was only a small leap of logic to realize that the converse was also true; if the satellite's position was known then they could identify their own position on Earth.

The first satellite navigation system, Transit, used by the US Navy, was first successfully tested in 1960. Using a constellation of five satellites, it could provide a navigational fix approximately once per hour. In 1967 the US Navy developed the Timation satellite which proved the ability to place accurate clocks in space, a technology the GPS system relies upon. In the 1970s, the ground-based Omega Navigation System, based on signal phase comparison, became the first world-wide radio navigation system.

The first experimental Block-I GPS satellite was launched in February 1978.[5] The GPS satellites were initially manufactured by Rockwell International and now manufactured by Lockheed Martin.

In 1983, after Soviet interceptor aircraft shot down the civilian airliner KAL 007 in restricted Soviet airspace, killing all 269 people on board, Ronald Reagan announced that the GPS system would be made available for civilian uses once it was completed

By 1985, ten more experimental Block-I satellites had been launched to validate the concept The first modern Block-II satellite was launched on 14th February 1989, achieved initial operational capability by December 1993 [6] and a complete constellation of 24 satellites was in orbit by 17th January 1994.

In 1996, recognizing the importance of GPS to civilian users as well as military users, President Bill Clinton issued a policy directive[7] declaring GPS to be a dual-use system and establishing an Interagency GPS Executive Board to manage it as a national asset

In 1998, Vice President Al Gore announced plans to upgrade GPS with two new civilian signals for enhanced user accuracy and reliability, particularly with respect to aviation safety.

In 2004, President George W. Bush updated the national policy, replacing the board with the National Space-Based Positioning, Navigation, and Timing Executive Committee.

The most recent launch was in September 2005. The oldest GPS satellite still in operation was launched in February 1989.

Technical description

Satellites

The GPS system uses a satellite constellation of at least 24 active satellites in intermediate circular orbits. The constellation also includes three spare satellites in orbit, in case of any failure. Each satellite circles the Earth exactly twice each day at an altitude of 20,200 kilometres (12,600 miles). The orbits are aligned so at least four satellites are always within line of sight from almost any place on Earth. [8] There are four active satellites in each of six orbital planes. Each orbit is inclined 55 degrees from the equatorial plane, and the right ascension of the ascending nodes are separated by

sixty degrees. [9]

GPS satellite on test rack

The flight paths of the satellites are measured by five monitor stations around the world (Hawaii, Kwajalein, Ascension Island, Diego Garcia, Colorado Springs). The master control station, at Schriever AFB, processes their combined observations and sends updates to the satellites through the stations at Ascension Island, Diego Garcia, and Kwajalein. The updates synchronize the atomic clocks on board each satellite to within one microsecond, and also adjust the ephemeris of the satellites' internal orbital model to match the observations of the satellites from the ground. [10]

Each satellite repeatedly re-broadcasts the exact time according to its internal atomic clock along with a digital data packet The data includes the orbital elements of the satellite's precise position, satellite status messages, and an almanac of the approximate position of every other active GPS satellite. The almanac lets GPS receivers use data from the strongest satellite signal to locate other satellites.

Receivers

GPS receivers calculate their current position (latitude, longitude, elevation), and the precise time, using the process of trilateration. This involves measuring the distance to at least four satellites by comparing the satellites' coded time signal (PRN Code) transmissions. The receiver calculates the orbit of each satellite based on information encoded in their radio signals, and measures the distance to each satellite, called a pseudorange, based on the time delay from when the satellite signals were sent until they were received.

In order to measure the delay, the satellite repeatedly sends a 1,023 bit long pseudo random sequence; the receiver calculates an identical sequence from a known seed number, and shifts it until the two sequences match. Each satellite uses a different sequence, which lets them share the same radio frequencies, using Code division multiple access, while still allowing receivers to identify each satellite.

Once the location and distance of each satellite is known, the receiver should theoretically be located at the intersection of four imaginary spheres, one around each satellite, with a radius equal to the time delay between the satellite and the receiver multiplied by the speed of the radio signals. In practice, GPS calculations are more complex for several reasons. One complication is that GPS receivers do not have atomic clocks, so the precise time is not known when the signals arrive. Fortunately, even the relatively simple clock within the receiver provides an accurate comparison of the timing of the signals from the different satellites. The receiver is able to determine exactly when the signals were received by adjusting its internal clock (and therefore the spheres' radii) so that the spheres intersect near one point.

One of biggest problems for GPS accuracy is that changing atmospheric conditions change the speed of the GPS signals unpredictably as they pass through the ionosphere. The effect is minimized when the satellite is directly overhead and becomes greater toward the horizon, as the satellite signals must travel through the greater "thickness" of the ionosphere as the angle increases Once the receiver's rough location is known, an internal mathematical model can be used to estimate and correct for the error

Because ionospheric delay affects the speed of radio waves differently based on their frequencies, the second frequency band (L2) was used to help eliminate this type of error. Some military and expensive survey-grade civilian receivers can compare the difference between the L1 and L2 frequencies to measure atmospheric delay and apply precise corrections.

GPS signals can also be affected by multipath issues, where the radio signals reflect off surrounding terrain-

buildings, canyon walls, hard ground, etc This delay in reaching the receiver causes inaccuracy. A variety of receiver techniques, most notably Narrow Correlator spacing, have been developed to mitigate multipath errors. For long delay multipath, the receiver itself can recognize the wayward signal and discard it. To address shorter delay multipath due to the signal reflecting off the ground, specialized antennas may be used. This form of multipath is harder to filter out as it is only slightly delayed as compared to the direct signal, causing effects almost indistinguishable from routine fluctuations in atmospheric delay.

Many GPS receivers can relay position data to a PC or other device using the NMEA 0183 protocol. NMEA 2000 [11] is a newer and less widely adopted protocol. Both are proprietary, and are controlled on a for-profit basis by the US-based National Marine Electronics Association. References to the NMEA protocols have been compiled from public records, allowing open source tools like *gpsd* to read the protocol without violating Intellectual property laws.

Frequencies

Several frequencies make up the GPS electromagnetic spectrum:

- L1 (1575.42 MHz):
  Carries a publicly usable coarse-acquisition (C/A) code as well as an encrypted precision P(Y) code.
- L2 (1227.60 MHz):
  Usually carries only the P(Y) code. The encryption keys required to directly use the P(Y) code are tightly controlled by the U.S. government and are generally provided only for military use. The keys are changed on a daily basis. In spite of not having the P(Y) code encryption key, several high-end GPS receiver manufacturers have developed techniques for utilizing this signal (in a round-about manner) to increase accuracy and remove error caused by the ionosphere. Recognizing the civilian need for increased accuracy, "modernized" IIR-M (IIR-14 (M) and later) satellites carry a civilian signal interleaved with an improved military signal on both the L1 and L2 frequencies.
- L3 (1381.05 MHz):
  Carries the signal for the GPS constellation's alternative role of detecting missile/rocket launches (supplementing Defense Support Program satellites), nuclear detonations, and other high-energy infrared events.
- L4 (1841.40 MHz):
  Being studied for additional ionospheric correction.
- L5 (1176.45 MHz):
  Proposed for use as a civilian safety-of-life (SoL) signal. This frequency falls into an internationally protected range for aeronautical navigation, promising little or no interference under all circumstances. The first Block IIF satellite that would provide this signal is set to be launched in 2008.

GPS and relativity

The clocks on the satellites are also affected by both special and general relativity, which causes them to run at a slightly faster rate than do clocks on the Earth's surface. This amounts to a discrepancy of around 38 microseconds per day. To account for this, the frequency standard on-board the satellites runs slightly slower than its desired speed on Earth, at 10.22999999543 MHz instead of 10.23 MHz.[12] This offset is a practical demonstration of the theory of relativity in a real-world system; it is exactly that predicted by the theory, within the limits of accuracy of measurement.

Neil Ashby presented a good account of how these relativistic corrections are applied, why, and their orders of magnitude, in *Physics Today* (May 2002).[13] Whether relativity must be considered as a mere correction to a Newtonian GPS theory, or, rather, as the necessary foundation of a cleaner (and more fundamental) GPS theory, is currently under debate. Bartolomé Coll has recently developed the basic notions necessary for a fully relativistic theory of Positioning Systems.[14]

Awards

Two GPS developers have received the National Academy of Engineering Charles Stark Draper prize year 2003:

- Ivan Getting, emeritus president of The Aerospace Corporation and engineer at the Massachusetts Institute of Technology, established the basis for GPS, improving on the World War II land-based radio system called LORAN (Long-range Radio Aid to Navigation).
- Bradford Parkinson, teacher of aeronautics and astronautics at Stanford University, developed the system.

One GPS developer, Roger L. Easton, received the National Medal of Technology on February 13, 2006 at the White House.[15]

On February 10, 1993, the National Aeronautic Association selected the Global Positioning System Team as winners of the 1992 Robert J Collier Trophy, the most prestigious aviation award in the United States. This team consists of researchers from the Naval Research Laboratory, the U.S. Air Force, the Aerospace Corporation, Rockwell International Corporation, and IBM Federal Systems Company. The citation accompanying the presentation of the trophy honors the GPS Team "for the most significant development for safe and efficient navigation and surveillance of air and spacecraft since the introduction of radio navigation 50 years ago "

Techniques to improve GPS accuracy

The accuracy of GPS can be improved in a number of ways:

- **Differential GPS (DGPS)** can improve the normal GPS accuracy of 4-20 meters to 1-3 meters [16] DGPS uses a network of stationary GPS receivers to calculate the difference between their actual known position and the position as calculated by their received GPS signal. The "difference" is broadcast as a local FM signal, allowing many civilian GPS receivers to "fix" the signal for greatly improved accuracy.
- The Wide Area Augmentation System (**WAAS**). This uses a series of ground reference stations to calculate GPS correction messages, which are uploaded to a series of additional satellites in geosynchronous orbit for transmission to GPS receivers, including information on ionospheric delays, individual satellite clock drift, and suchlike. Although only a few WAAS satellites are currently available as of 2004, it is hoped that eventually WAAS will provide sufficient reliability and accuracy that it can be used for critical applications such as GPS-based instrument approaches in aviation (landing an airplane in conditions of little or no visibility). The current WAAS system only works for North America (where the reference stations are located), and due to the satellite location the system is only generally usable in the eastern and western coastal regions. However, variants of the WAAS system are being developed in Europe (EGNOS, the Euro Geostationary Navigation Overlay Service), and Japan (**MSAS**, the Multi-Functional Satellite Augmentation System), which are virtually identical to WAAS.
- A Local Area Augmentation System (**LAAS**). This is similar to WAAS, in that similar correction data are used. But in this case, the correction data are transmitted from a local source, typically at an airport or another location where accurate positioning is needed. These correction data are typically useful for only about a thirty to fifty kilometer radius around the transmitter.
- Exploitation of DGPS for Guidance Enhancement (**EDGE**) is an effort to integrate DGPS into precision guided munitions such as the Joint Direct Attack Munition (**JDAM**).
- A Carrier-Phase Enhancement (**CPGPS**). This technique utilizes the 1.575 GHz L1 carrier wave to act as a sort of clock signal, resolving ambiguity caused by variations in the location of the pulse transition (logic 1-0 or 0-1) of the C/A PRN signal. The problem arises from the fact that the transition from 0-1 or 1-0 on the C/A signal is not instantaneous, it takes a non-zero amount of time, and thus the correlation (satellite-receiver sequence matching) operation is imperfect A successful correlation could be defined in a number of various places along the rising/falling edge of the pulse, which imparts timing errors. CPGPS solves this problem by using the L1 carrier, which has a period 1/1000 that of the C/A bit width, to define the transition point instead. The phase difference error in the normal GPS amounts to a 2-3 m ambiguity.

CPGPS working to within 1% of perfect transition matching can achieve 3 mm ambiguity; in reality, CPGPS coupled with DGPS normally realizes 20-30 cm accuracy.

- Wide Area GPS Enhancement (**WAGE**) is an attempt to improve GPS accuracy by providing more accurate satellite clock and ephemeris (orbital) data to specially-equipped receivers.
- Relative Kinematic Positioning (**RKP**) is another approach for a precise GPS-based positioning system. In this approach, accurate determination of range signal can be resolved to an accuracy of less than 10 centimetres. This is done by resolving the number of cycles in which the signal is transmitted and received by the receiver This can be accomplished by using a combination of differential GPS (DGPS) correction data, transmitting GPS signal phase information and ambiguity resolution techniques via statistical tests—possibly with processing in real-time (real-time kinematic positioning, RTK).
- Many automobiles that use the GPS combine the GPS unit with a gyroscope and speedometer pickup, allowing the computer to maintain a continuous navigation solution by dead reckoning when buildings, terrain, or tunnels block the satellite signals. This is similar in principle to the combination of GPS and inertial navigation used in ships and aircraft, but less accurate and less expensive because it only fills in for short periods.

Selective availability

When it was first deployed, GPS included a feature called **Selective Availability** (or **SA**) that introduced intentional errors of up to a hundred meters into the publicly available navigation signals, making it difficult to use for guiding long range missiles to precise targets. Additional accuracy was available in the signal, but in an encrypted form that was only available to the United States military, its allies and a few others, mostly government users.

SA typically added signal errors of up to about 10 m horizontally and 30 m vertically. The inaccuracy of the civilian signal was deliberately encoded so as not to change very quickly, for instance the entire eastern US area might read 30 m off, but 30 m off everywhere and in the same direction. In order to improve the usefulness of GPS for civilian navigation, **Differential GPS** was used by many civilian GPS receivers to greatly improve accuracy.

During the Gulf War, the shortage of military GPS units and the wide availability of civilian ones among personnel resulted in disabling the Selective Availability. In the 1990s the FAA started pressuring the military to turn off SA permanently. This would save the FAA millions of dollars every year in maintenance of their own radio navigation systems. The military resisted for most of the 1990s, but SA was eventually turned off[17] in 2000 following an announcement by then US President Bill Clinton, allowing users access to an undegraded L1 signal.

The US military has developed the ability to locally deny GPS (and other navigation services) to hostile forces in a specific area of crisis without affecting the rest of the world or its own military systems. Such **Navigation Warfare** uses techniques such as local jamming to replace the blunt, world-wide degradation of civilian GPS service that SA represented.

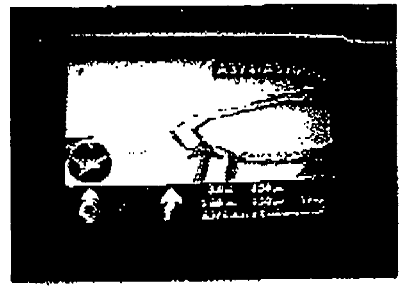
Military (and selected civilian) users still enjoy some technical advantages which can give quicker satellite lock and increased accuracy The increased accuracy comes mostly from being able to use both the L1 and L2 frequencies and thus better compensate for the varying signal delay in the ionosphere (see above).

- SA Announcements (http://pnt.gov/public/sa/)

GPS tracking

Main article. GPS tracking

A GPS tracking system uses GPS to determine the location of a vehicle, person, or pet and to record the position at regular intervals in order to create a track file or log of activities. The recorded data can be stored within the tracking unit, or it may be transmitted to a central location, or internet-connected computer, using a cellular modem, 2-way radio, or satellite. This allows the data to be reported in real-time, using either web browser based tools or customized software.


GPS Navigation using the TomTom software

GPS jamming

Further information: Selective Availability / Anti-Spoofing Module

Jamming of any radio navigation system, including satellite based navigation, is possible. The U S Air Force conducted GPS jamming exercises in 2003 and they also have GPS anti-spoofing capabilities. In 2002, a detailed description of how to build a short range GPS L1 C/A jammer was published in Phrack issue 60[18] by an anonymous author. There has also been at least one well-documented case of unintentional jamming, it traced back to a malfunctioning TV antenna preamplifier.[19] If stronger signals were generated intentionally, they could potentially interfere with aviation GPS receivers within line of sight. According to John Ruley, of AVweb, "IFR pilots should have a fallback plan in case of a GPS malfunction".[20] Receiver Autonomous Integrity Monitoring (RAIM), a feature of some aviation and marine receivers, is designed to provide a warning to the user if jamming or another problem is detected. There are also incidents of unintentional jamming. GPS signals can also be interfered with by natural geomagnetic storms, predominantly at high latitudes.[21]

GPS jammers the size of a cigarette box are allegedly available from Russia, their effectiveness is in question following their use in the Iraq war. The U.S. government believes that such jammers were also used occasionally during the U.S. invasion of Afghanistan. Some officials believe that jammers could be used to attract the precision-guided munitions towards non-combatant infrastructure, other officials believe that the jammers are completely ineffective. In either case, the jammers may be attractive targets for anti-radiation missiles. Low power jammers would have limited military usefulness and high power jammers would be easy to locate and destroy. During the Iraq war, the US military claimed to destroy a GPS jammer with a GPS-guided bomb. [22]

Other systems

Russia operates an independent system called GLONASS (**GLO**bal **NA**vigation Satellite System), although with only twelve active satellites as of 2004, the system is of limited usefulness. There are plans to restore GLONASS to full operation by 2008. The European Union is developing Galileo as an alternative to GPS, planned to be in operation by 2010 China and France are also developing other satellite navigation systems.

Satellite navigation systems
Transit | **GPS** | **GLONASS** | **Galileo** | **Beidou**
Related topics. EGNOS | WAAS | LAAS

See also

- Wikipedia Geographical coordinates project - adding geographic coordinates to WikiPedia articles
- Degree Confluence Project Use GPS to visit integral

Find more information on **Global Positioning System** by searching Wikipedia's sister projects:

degrees of latitude and longitude.

- Geodashing, an outdoor sport using waypoints
- WikiGPS, Wikimedia proposed project.
- World Geodetic System - **WGS 84** datum is commonly used to represent GPS coordinates
- The American Practical Navigator - Satellite navigation, Chapter 11

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External links

- Peter H. Dana: Global Positioning System Overview (http://www.colorado.edu/geography/gcraft/notes/gps/gps_f.html) - Large amount of technical information and discussion.
- GPS SPS Signal Specification, 2nd Edition (http://www.navcen.uscg.gov/pubs/gps/sigspec/default.htm) - The official (civilian) signal specification.
- History of GPS (http://www.astronautix com/project/navstar.htm), including information about each satellite's configuration and launch.
- U.S. Army Corps of Engineers manual: NAVSTAR HTML (http://www.usace.army.mil/inet/usace-docs/eng-manuals/em1110-1-1003/toc.htm) and PDF (22.6 MB, 328 pages) (http://www.usace.army.mil/inet/usace-docs/eng-manuals/em1110-1-1003/entire.pdf)
- The Global Positioning System: Challenges in Bringing GPS to Mainstream Consumers (http://netlab18.cis.nctu.edu.tw/html/paper/2001_11_06/Challenges%20in%20bringing%20GPS%20to%20Mainstream%20Consumers.pdf) Technical Article by Kanwar Chadha, BSEE (1998)
- USCG Navigation Center (http://www.navcen.uscg.gov/gps/default.htm), Status of the GPS constellation, government policy, and links to other references. Also includes satellite almanac data.
- Schriever Airforce Base Webserver (https://www.schriever.af.mil/gps/archive/2005/), Almanac data and NANUs
- National Space-Based PNT Executive Committee (http.//pnt.gov/) - Established in 2004 to oversee management of GPS and GPS augmentations at a national level.
- The GPS Joint Program Office (GPS JPO) (http://gps.losangeles.af.mil/) - Responsible for designing and acquiring the system on behalf of the US Government
- FAA GPS faq (http://gps.faa.gov/FAQ/index.htm)
- GPS Weapon Guidance Techniques (http://www.defense-update com/products/g/gps-guidance.htm)

Usenet newsgroups

- sci.geo.satellite-nav Direct (news:sci.geo.satellite-nav) or via the Google Groups (http://groups-beta.google.com/group/sci.geo.satellite-nav) web site.
- uk.rec.gps Direct (news:uk.rec.gps) or via the Google Groups (http://groups-beta.google com/group/uk.rec.gps) web site.

Other information

- University of New Brunswick, In Simple Terms, How Does GPS Work? (http://gge.unb.ca/Resources/HowDoesGPSWork.html)
- u-blox GPS Tutorial (PDF) (http://www.u-blox.com/technology/GPS-X-02007.pdf) — Tutorial designed to introduce you to the principles behind GPS
- Trimble's Online GPS Tutorial (http://www.trimble.com/gps/) — excellent introduction for newbies
- RAND history of the GPS system (PDF) (http://www.rand.org/publications/MR/MR614/MR614.appb.pdf)
- GPS Anti-Jam Protection Techniques (http://www.defense-update.com/products/g/gps-aj.htm)

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